Conversion Technologies For Municipal Residuals

A Background Primer
Prepared by CIWMB Staff

May 3-4, 2001
Sacramento, California

This paper has been prepared solely for the purpose of providing background information for the "Conversion Technologies For Municipal Residuals" forum being held May 3-4, 2001, in Sacramento, California. The paper has not been peer-reviewed and does not represent any specific views or policies of the California Integrated Waste Management Board. The technologies described herein do not necessarily represent the entire range of conversion technologies being proposed or developed. Staff welcomes suggestions for additional information that is relevant to the topics discussed herein.

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I. INTRODUCTION/VISIONS

The Future

Visualize millions of tons of yard trimmings and wood that cannot be composted, of low-value paper and plastic residuals from material recovery facilities (MRFs) for which there is no recycling market demand, and of agricultural residues that can no longer be burned in fields. All of these materials are either landfilled today or might be headed for landfills tomorrow. Now imagine a future where unwanted materials destined for landfills instead are converted into high-value products such as energy, ethanol and other fuels, and citric acid and other industrial products. That future could revolve around a new generation of "conversion" technologies, such as hydrolysis, gasification, and anaerobic digestion.

These technologies have potential to help solve vexing environmental problems and could help achieve some of Cal/EPA's Strategic Vision and goals, including continuous improvement and application of science and technology and ensuring the efficient use of natural resources. At the same time, they should be examined with the idea in mind that solving one environmental problem should not create other problems – i.e., within a framework that considers cross-media and sustainability implications.

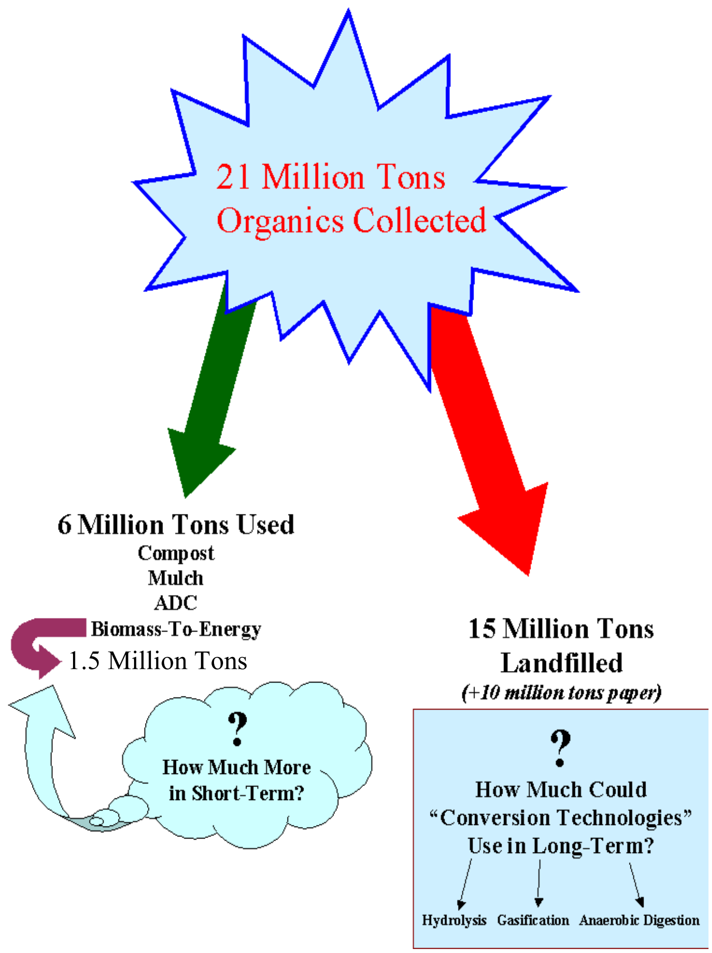
These technologies will be the subject of a California Integrated Waste Management Board (CIWMB) forum being held on May 3-4, 2001, in Sacramento, California. The objectives of the forum are multiple: 1) to build a shared understanding of issues, concerns, and interests regarding municipal residuals, conversion technologies, and related laws and policies; 2) to gather input from a wide range of stakeholders and interest groups on opportunities, barriers, and possible solutions; and 3) to develop a set of recommendations that can be presented to the California Integrated Waste Management Board for further discussion. This forum is the first public discussion of this topic since a seminal meeting held in December 1999 in Santa Barbara, California, under the auspices of the Community Environmental Council and sponsored by the Wendy P. McCaw Foundation and MSW Management Magazine.

The Past and Present

In pursuit of its mission to foster solid waste prevention, reuse, and recycling, the CIWMB has made a concerted effort to target large components of the waste stream -- organic materials being one priority. For this group of materials, the CIWMB has focused on preventing on-site generation and on developing markets for compost and mulch. However, despite the rapid growth of composting and other management techniques in the last 10 years, organic materials still made up 35 to 40 percent – about 15 million tons -- of what was disposed in 1999. (In addition, paper consisted of 30 percent, woody construction debris 5 percent, and plastics 9 percent.)

Once organic materials are collected, they typically are processed into compost, mulch, alternative daily cover, and biomass-to-energy feedstock. The flow of organic materials is illustrated in Figure 1 and described directly below.

Figure 1. Organic Materials in California

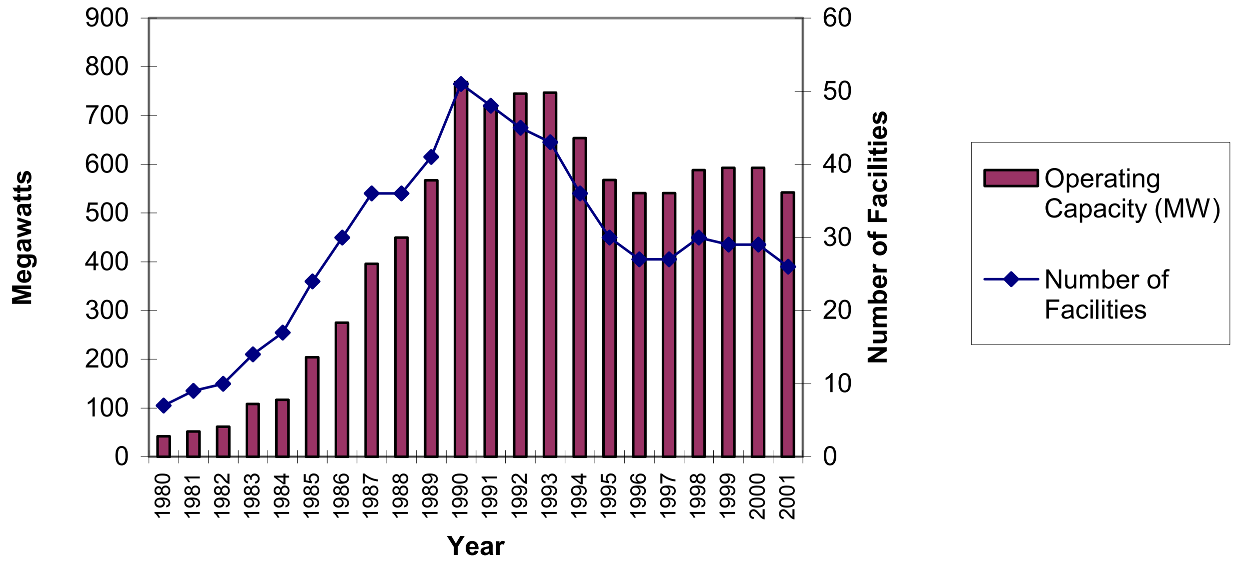


In the early 1990s, there were less than 10 permitted composting facilities. These facilities used approximately 1 to 2 million tons of urban organics annually. Today, about 170 composting and mulching operations exist in California, including about 87 permitted composting facilities. These operations use approximately 6 to 8 million tons per year of urban organic materials (including about 1.5 million tons that are used as biomass-to-energy fuel). While this is a large increase from the early 1990s, it still is only about one-third of the organic materials that are collected (the remaining 2/3, some 15 million tons, are landfilled). Thus, existing market demand is sufficient only for about 1/3 of collected organic materials.

With respect to biomass-to-energy, in 1990 there were over 50 facilities with a generating capacity of almost 800 megawatts. These energy plants burned over ten million tons per year of woody debris from logging and sawmill operations, urban sources, and agriculture, some of which would have gone to landfills had the facilities not been operating.

With the advent of electricity deregulation, many plants have closed (Figure 2). They previously had contracts guaranteeing higher-than-market prices for the energy they generated, but most of these contracts have expired and with deregulation many were unable to compete in the open market. In 1999, there were 29 operating biomass-to-energy plants that used 6.5 million tons of biomass material. Of this, about 1.5 million tons was urban wood waste (as noted above, this is included in the 6 to 8 million tons of materials processed by compost and mulch operators). Currently there are 26 operating biomass-to-energy facilities.

Figure 2. California Biomass-to-Energy Facilities and Capacity



II. BACK TO THE FUTURE: SCENARIOS OF WHAT MIGHT HAPPEN

Several scenarios could play out in the future. This section first describes what might happen if current trends in waste management and disposal continue. It then describes two alternative scenarios, among many that are possible, that involve using hydrolysis and gasification to convert materials otherwise destined for landfills into valuable products. Hydrolysis currently is used in the midwestern United States to convert corn residue into ethanol. Gasification is used in Australia to convert sorted municipal solid waste into energy.

An Unwanted Future

As illustrated in Figure 1, approximately 15 million tons of organic materials and an additional 10 million tons of low-grade paper are currently landfilled; much of this material consists of residuals from material recovery facilities (MRFs) for which there is no recycling market demand. In addition, without increased prevention, reuse, and recycling efforts, the amount of organic materials and paper sent to landfills is likely to increase due to population growth.

Moreover, if existing biomass-to-energy plants that use woody materials and agricultural residues as feedstocks continue to close, millions of more tons may also end up being landfilled. Table 1, which excerpts data from a study conducted by the U.S. Department of Energy's National Renewable Energy Laboratory (NREL), shows potential disposal and management options for biomass feedstocks if the biomass-to-energy industry experiences a total collapse.

Table 1. NREL Estimates of Alternative Management Options in California for Biomass Fuels Under a Total Collapse Scenario for the Biomass-to-Energy Industry

Alternative Management/Disposal Method	Annual Tons
Open Burning	1.7 Million
Forest Accumulation	490,000
Landfilling	3 Million
Compost/Mulch	370,000
Kiln Boiler	886,000
Total	**6.5 Million (rounded)**

This situation may be further exacerbated by bans on the burning of rice straw and other agricultural residues. Approximately 500,000 acres of rice are planted annually in California, resulting in a large amount of rice straw residual. Current law requires a progressive phase down in rice straw burning. Beginning in September 2001, rice straw burning will be allowed for disease control only and will be limited to 25 percent of planted acres or 125,000 acres, whichever is less. One alternative to open-field burning is the incorporation of the rice straw into the soil; however, this may result in an increase in rice diseases with repeated straw incorporation.[1]

These trends may profoundly impact both the ability of local jurisdictions to meet diversion requirements and the longevity of landfills around the state. Therefore, the CIWMB is interested in examining new, innovative market opportunities to utilize these materials. What role can conversion technologies such as hydrolysis and gasification play in taking materials generally considered waste and making them valuable commodities that can be converted to ethanol, energy, or other products? The remainder of this section describes two examples of the opportunities to incorporate conversion technologies within the existing recycling and solid waste infrastructure. These examples are presented merely for illustrative purposes and should not be considered an endorsement of hydrolysis or gasification over other conversion technologies.

Hydrolysis to Ethanol Scenario

One possible scenario involves the use of hydrolysis to produce ethanol (see Section III, “Description of Technologies and Existing/Planned Facilities,” for a more detailed description of hydrolysis). Interest in this scenario is high because ethanol can serve as a replacement for methyl tertiary butyl ether (MTBE) as a gasoline additive.

With the phase out of MTBE as a gasoline additive due to its impact on water quality, annual demand in California for ethanol as a replacement for MTBE may reach approximately 1 billion gallons by 2002. Current ethanol production capacity in California is estimated to be 12 million gallons annually, with the bulk of the demand currently being met by ethanol imports from the Midwest.

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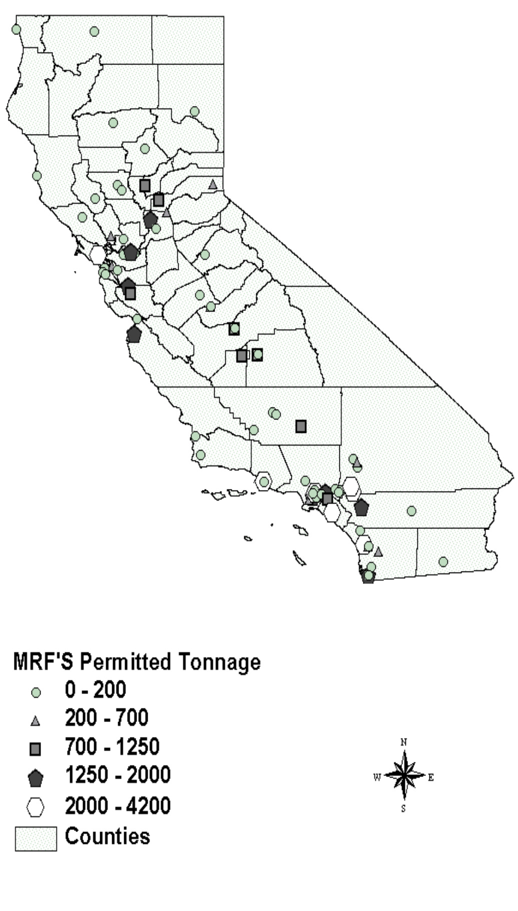
[1] California Air Resources Board, “Progress Report on the Phase Down of Rice Straw Burning in the Sacramento Valley, “ February 2000.

Materials available in California, such as rice straw and urban residuals, may be amenable feedstocks for conversion to ethanol. The California Energy Commission's (CEC) 1999 study, "Evaluation of Biomass-to-Ethanol Fuel Potential in California," included 65 modeled scenarios using a variety of feedstocks and ethanol plant sizes. One set of scenarios used urban residuals as a feedstock, with feedstock requirements ranging from 836 to 2,965 tons per day (293,000 to 390,000 tons per year, bone dry).

The CEC recently approved a follow-up report, "Costs and Benefits of a Biomass-to-Ethanol Production Industry in California." This report also included modeled ethanol production scenarios using urban residuals as a feedstock; however, the tonnage figures used were quite a bit lower than the CEC's 1999 Report. The findings of the CEC's most recent report indicate that four ethanol facilities using urban residuals as feedstock could divert 400,000 tons per year of materials from landfills and produce 40 million gallons of ethanol (10 million gallons per facility).

Figure 3 – California Materials Recovery Facilities



Ethanol facilities could be located in urban areas. For example, they could be co-located at MRFs where existing materials are already collected and the existing solid waste transportation infrastructure could be utilized. Figure 3 shows the location and size of MRFs in California. As the map illustrates, the larger MRFs (i.e., ones that process more than 2,000 tons per day) are located in Southern California and the San Francisco Bay Area. However, if each ethanol facility only requires 100,000 tons per year of feedstock, which translates to approximately 290 tons per day of residuals (based on 350 operating days), the number of potential locations for an ethanol facility increases dramatically. For example, there are 21 MRFs that range in tonnage from 700 to 4,200 tons per day. If ten ethanol production facilities are constructed and each converts 290 tons per day, then the result would be a total annual conversion of 1 million tons of MRF residuals into 100 million gallons of ethanol.

As noted, ethanol facilities co-located at MRFs could take advantage of the existing solid waste collection and transportation infrastructure. In addition, ethanol conversion facilities in the Sacramento/San Joaquin Valley could use the existing rail system for transportation of ethanol to the appropriate blending facilities. At the same time, siting any facility is no easy task. Questions regarding siting and permitting issues are presented in Section VI ("Barriers to Developing Conversion Technologies").

Gasification to Energy Scenario

Another option is the use of gasification, which can convert agricultural, forestry, and MRF residuals into a synthetic gas (syngas) that can be used to produce electricity (see Section III, "Description of Technologies and Existing/Planned Facilities," for a more detailed description of gasification). For example, one gasification technology can convert 1000 tons per day of MRF residuals (which would be landfilled anyway) and produce close to 25 MW of electricity. Using this technology as an example, 10 gasification facilities utilizing 10,000 tons per day would have a generating capacity of 250 MW of electricity. Assuming 350 operating days, the 10 gasification facilities could divert 3.5 million tons annually of materials that would otherwise have been landfilled. In comparison, the 26 existing biomass-to-energy plants use about 6 million tons of organic residuals (1.5 million tons of which are urban woody residuals) and have a generating capacity of about 550 MW. As illustrated in Figure 2, the number of operating biomass-to-energy facilities continues to decline, and it is uncertain whether any mothballed facilities will be restarted.

As in the case of ethanol conversion facilities, gasification facilities could be co-located at MRFs to take advantage of the current solid waste transportation infrastructure. In addition, co-location at MRFs would ensure that recyclable materials would be removed beforehand and only residuals would be sent to a gasifier. If a gasification facility is co-located at a landfill that accepts MRF residuals, the gasification facility could utilize landfill gas in the gasification process or could work in tandem with a landfill gas-to-electricity project.

III. DESCRIPTION OF TECHNOLOGIES AND EXISTING/PLANNED FACILITIES

Technologies that appear amenable for converting organic and other materials into energy, ethanol, and other products include hydrolysis, gasification, anaerobic digestion, and plasma arc. The following sections briefly describe these technologies; Table 2 provides a very general comparative overview of these technologies.

Table 2. General Overview of Conversion Technologies

Technology	Amenable Feedstock	Feedstock Requirements	Emissions/Residues
Acid Hydrolysis	Cellulosic material	Cellulosic feedstock	Wastewater, CO_2
Enzyme Hydrolysis	Cellulosic material	Cellulosic feedstock	Wastewater, CO_2
Gasification	Biomass, MSW	Drier feedstock, high carbon	Ammonia, NO_x, tars, oil
Anaerobic Digestion	Manure, biosolids	Wet material, High nitrogen	Wastewater, CH_4, CO_2, H_2S
Plasma Arc	MSW	?	Slag, scrubber water

Hydrolysis

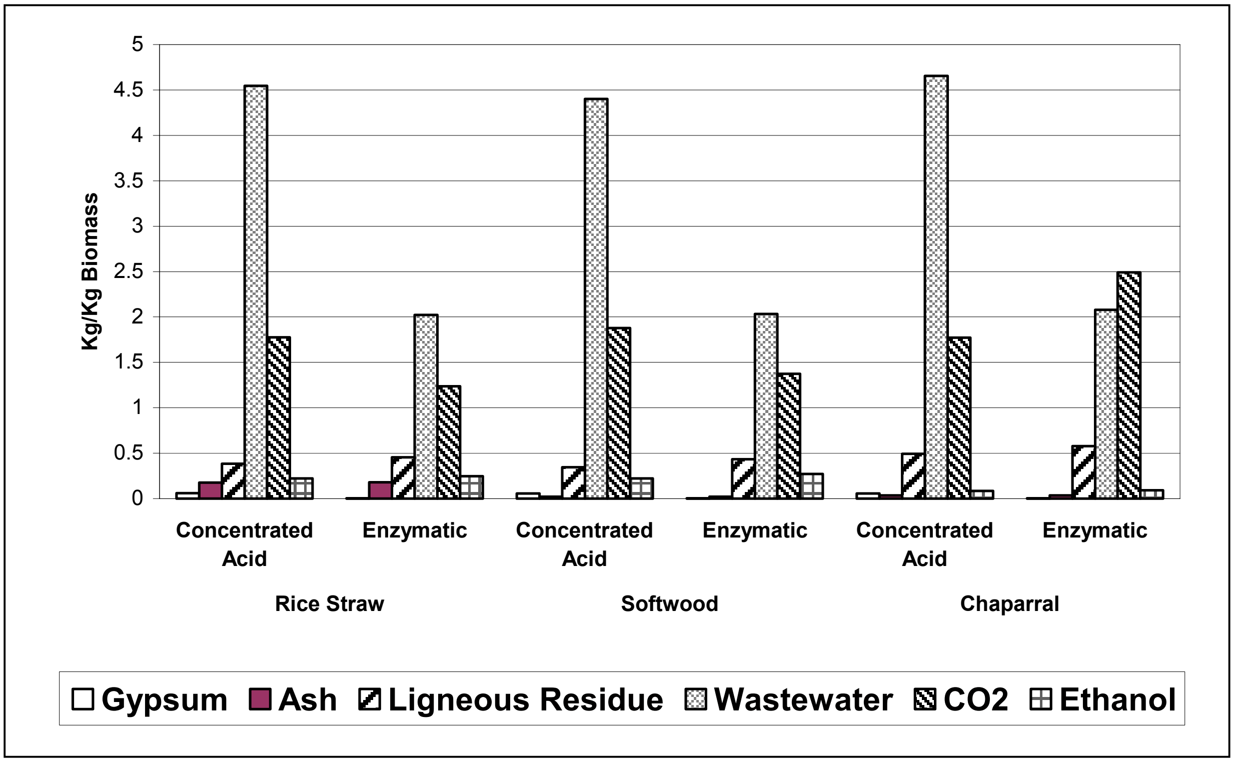
Hydrolysis is a chemical process of decomposition involving the use of water to split chemical bonds of substances. There are two types of hydrolysis, acid and enzymatic. Feedstocks that may be appropriate for acid or enzymatic hydrolysis typically are plant-based materials containing cellulose, such as forest material and sawmill residue, agricultural residue, urban waste, and waste paper.

All plants have structural components composed of lignocellulosic fibers, which in turn are comprised of three major fractions: cellulose, hemicellulose, and lignin. Cellulose and hemicellulose are chains of sugar molecules that can be broken down chemically or biologically into the component sugars. The sugars are then fermented, using yeast or bacteria, to produce ethanol, and the ethanol is distilled to a higher concentration for final use. Lignin, which acts as a binder that holds cellulose and hemicellulose together, cannot be broken down to sugars. At this point, the most cost-effective use for lignins is as a fuel for biomass-to-energy facilities.

Sugars can also be converted to levulinic acid and citric acid. Levulinic acid is a versatile chemical that is a precursor to other specialty chemicals, fuels and fuels additives, herbicides, and pesticides. The largest application for citric acid is in the beverage industry, which accounts for about 45 percent of the market for this product. Citric acid is also used in a wide variety of candies, frozen foods, and processed cheeses and as a preservative in canned goods, meats, jellies, and preserves.

NREL's report, "Environmental Life Cycle Implications of Fuel Oxygenate Production from California Biomass," included information on potential emissions from both acid and enzymatic hydrolysis of rice straw, forest residue, and chaparral (Figure 4).

Figure 4. Potential Emissions from Acid and Enzymatic Hydrolysis



The two largest potential impacts from acid and enzymatic hydrolysis are the large amounts of wastewater and CO_2 produced. The wastewater would be sent to a treatment plant for appropriate management. Emissions of CO_2 from the fermentation process would be released into the atmosphere.

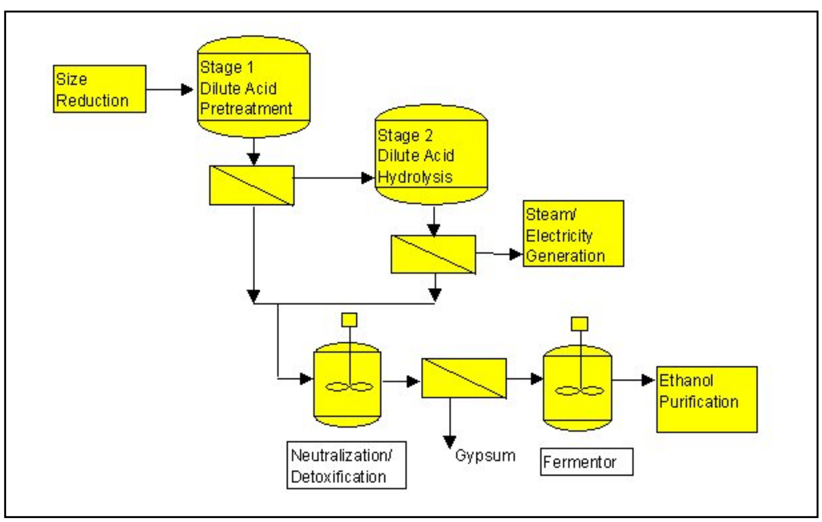
CIWMB staff are unaware of any existing commercial hydrolysis plants that use MRF residuals as feedstock, which means that there is no information available on actual emissions and environmental performance using this feedstock.

Acid Hydrolysis

In acid hydrolysis, acid is used in either dilute or concentrated form as a medium to hydrolyze cellulose and hemicellulose. The acid hydrolysis process consists of four basic operations:

1. Hydrolysis
2. Separation of acids and sugars
3. Ethanol fermentation
4. Product purification

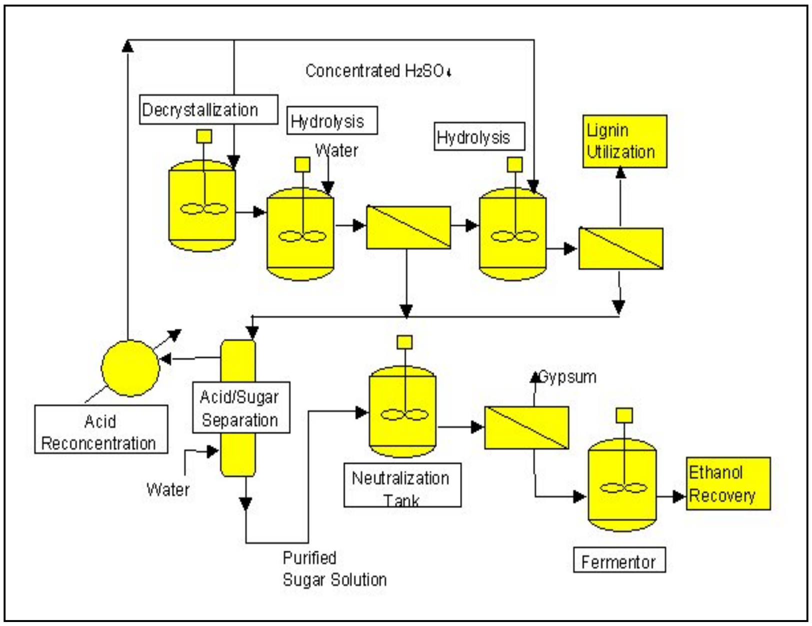
Figure 5. Dilute Acid Hydrolysis



Source: Office of Fuels Development, U.S. Dept. of Energy

The use of dilute acid hydrolysis is the oldest technology for converting biomass into its component sugars for subsequent fermentation to ethanol. Figure 5 illustrates the dilute acid process. The hydrolysis occurs in two stages to accommodate the differences between hemicellulose and cellulose. Cellulose is protected from hydrolysis by a sheath of hemicellulose and lignin, so the first stage, which occurs under milder conditions, maximizes the yield of the more easily hydrolyzed hemicellulose and exposes cellulose for the second stage of hydrolysis.[2] The second stage is optimized for hydrolysis of the more resistant cellulose fraction. Hydrolysis using strong acid is very similar to dilute acid hydrolysis, with the exception that the acid concentration is much greater and the process temperature is lower.

Figure 6. Concentrated Acid Hydrolysis



Source: Office of Fuels Development, U.S. Dept. of Energy

The concentrated acid process includes a step to separate the acid-sugar stream through a separation column that yields a 25% concentrated acid stream and a 12 to 15% concentrated sugar stream. The sugar recovery is 95%, whereas the acid recovery is 98%. The acid stream is concentrated and recycled for subsequent hydrolysis. The sugar stream, which contains no more than 1% acid, can then be fermented. Residual acids in the sugar stream can be neutralized using lime. The use of lime as a neutralizing agent yields gypsum, which can be sold as a soil amendment or to wallboard manufacturers. Figure 6 illustrates the concentrated acid process.

The liquid fractions are recovered from each hydrolysis step and fermented to alcohol using yeast. Ethanol is separated from the fermentation broth by conventional distillation technology and dehydrated to yield fuel grade ethanol. The remaining liquid broth is sent to a wastewater treatment facility for appropriate management. Residual cellulose and lignin left over in the solids from the hydrolysis reactors can be used as boiler fuel for electricity or steam production.[3]

[2] California Energy Commission, "*Appendices, Evaluation of Biomass to Ethanol Fuel Potential in California,"* December 1999

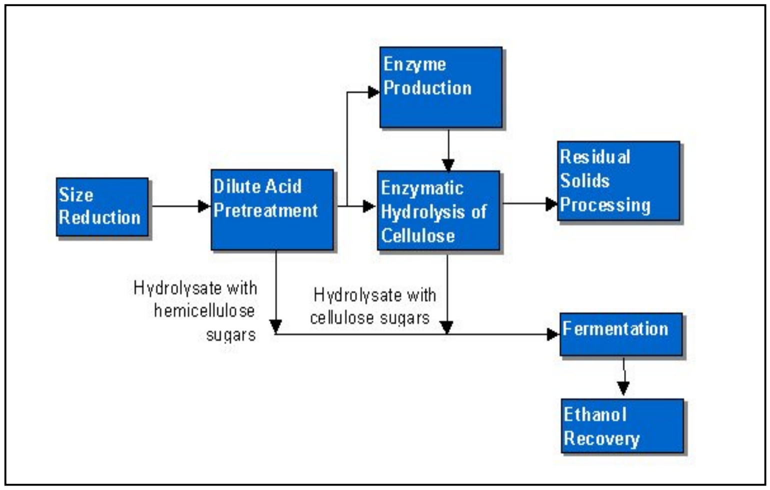
[3] Kadam, K.L., V.J. Camobreco, B.E. Glazebrook, et al, *"Environmental Life Cycle Implications of Fuel Oxygenate Production from California Biomass."* National Renewable Energy Laboratory (Boulder, CO), NREL/TP-580-25688, May 1999

Enzymatic Hydrolysis

The process for enzyme hydrolysis, illustrated in Figure 7, can be generalized in the following manner:

1. Pretreatment
2. Enzyme production
3. Ethanol production
4. Product purification

Figure 7. Enzymatic Hydrolysis



Source: Office of Fuels Development, U.S. Dept. of Energy

Enzymes typically used for hydrolysis are derived from common fungi. The enzymes produced by fungi are called cellulases because of their effectiveness in breaking down cellulose into its component sugar — glucose. Feedstocks appropriate for enzymatic hydrolysis include agricultural residues, waste paper, woody debris, green material, etc. The feedstock must be pretreated by a combination of physical, chemical, or biological means prior to hydrolysis.

Acids used during the pretreatment step are neutralized by the application of lime that yields gypsum as a residue. The gypsum residue can subsequently be used as a soil amendment.

Anaerobic Digestion

Anaerobic digestion is the bacterial breakdown of organic material in the absence of oxygen. This biological process produces a gas, sometimes called biogas, principally composed of methane (CH_4) and carbon dioxide (CO_2). This gas is produced from feedstocks such as sewage sludge, livestock manure, and other wet organic materials.

The process of anaerobic digestion typically consists of three steps:

1. Decomposition of plant or animal matter by bacteria into molecules such as sugar
2. Conversion of decomposed matter to organic acids
3. Organic acid conversion to methane gas

Anaerobic processes can occur naturally or in a controlled environment such as a biogas plant. In controlled environments, organic materials such as sewage sludge and other relatively wet organic materials, along with various types of bacteria, are put in an airtight container called a digester where the process occurs. Depending on the waste feedstock and the system design, biogas is typically 55 to 75 percent pure methane, although state-of-the-art systems report producing biogas that is more than 95 percent pure methane.

There are two basic anaerobic digestion processes, determined by the temperature range required for operation:

(i) Mesophilic digestion operates at temperatures of 20 to 45 C and the feedstock typically remains within the digester for 15 to 30 days. Compared with the thermophilic process (see below), mesophilic digestion tends to be more robust and tolerant to variation in feedstock and operating conditions. However, gas production is less, larger digestion tanks are required, and pathogen reduction, if required, would necessitate a separate process stage such as composting.

(ii) Thermophilic digestion operates at temperatures above 45 C and the residence time is typically 12 to 14 days. Compared with mesophilic digestion, thermophilic digestion systems offer higher methane production, faster throughput, and better pathogen and virus reduction, but they require more expensive technology, greater energy input, and a higher degree of operation and monitoring.

In addition to the two anaerobic digestion processes, the digester itself consists of several components: feedstock storage, feedstock handling, digestion tank, gas collection system, and residuals recovery system. The materials in the digestion tank must be mixed, so a mixing system is required as well. This can be accomplished mechanically in the tank or by recirculating the biogas through the tank.

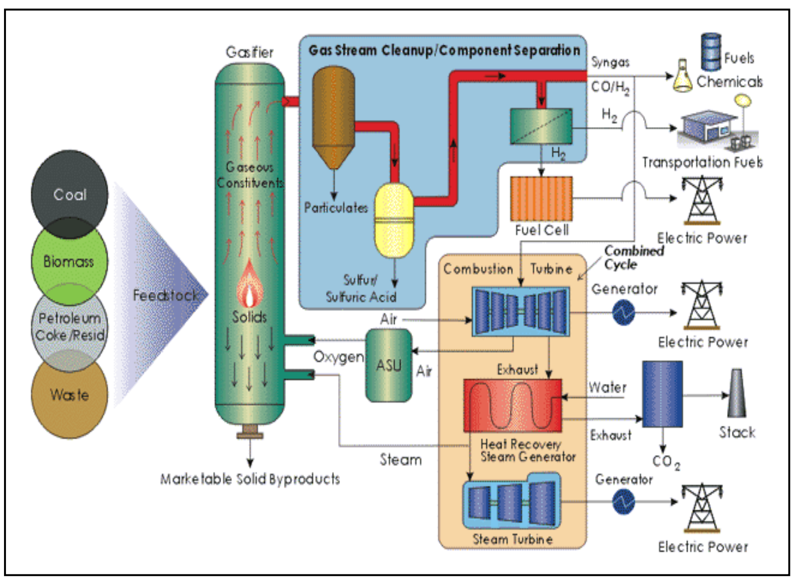
Emissions from anaerobic digestion depend on the type of material being digested, the method of digestion, and how optimally the digester is operating. Generally speaking, emissions or byproducts that can cause some environmental impact if not managed appropriately include wastewater and fugitive biogas (CH_4, CO_2, hydrogen sulfide).

Gasification

Gasification is a process that uses heat, pressure, and steam to convert materials directly into a gas composed primarily of carbon monoxide and hydrogen. Gasification technologies differ in many aspects but rely on four key engineering factors:

1. Gasification reactor atmosphere (level of oxygen or air content)
2. Reactor design
3. Internal and external heating
4. Operating temperature

Figure 7. Gasification



Typical raw materials used in gasification are coal, petroleum-based materials, and organic materials. The feedstock is prepared and fed, in either dry or slurried form, to a sealed reactor chamber called a gasifier. The feedstock is subjected to high heat, pressure, and either an oxygen-rich or oxygen-starved environment within the gasifier. Most commercial gasification technologies do not use oxygen. All require an energy source to generate heat and begin processing.

There are three primary products from gasification:
1. Hydrocarbon gases (also called syngas)
2. Hydrocarbon liquids (oils)
3. Char (carbon black and ash)

Syngas is made up primarily of carbon monoxide and hydrogen (more than 85 percent by volume) and smaller quantities of carbon dioxide and methane. Syngas can be used as a fuel to generate electricity or steam, or as a basic chemical building block for a multitude of uses. When mixed with air, syngas can be used in gasoline or diesel engines with few modifications to the engine.

As with anaerobic digestion, gasification emissions depend on the type of material being gasified, the particular gasification system, and how optimally the system is operating. Generally speaking, emissions or byproducts that can cause some environmental impact if not managed appropriately include mineral matter and particulates in the form of ash, and nitrogenous products such as ammonia and NOx. Volatile organic emissions in the form of tars and oils may also be problematic from a system that is not working optimally.[4] The inorganic material in the feedstock is converted to slag, which is inert and has a variety of uses in the construction and building industries.

Plasma Arc

Plasma arc technology is a non-incineration thermal process that uses extremely high temperatures in an oxygen-starved environment to completely decompose waste into very simple molecules. Plasma arc technology has been used for many years for metals processing. The heat source is a plasma arc torch, a device that produces a very high temperature plasma gas. A plasma gas is the hottest, sustainable heat source available, with temperatures ranging from 2700 to 12,000 degrees Fahrenheit. A plasma arc system is designed specifically for the type, size and quantity of waste material to be processed. The very high temperature profile of the plasma gas provides an optimal processing zone with the reactor vessel through which all input material is forced to pass. The reactor vessel operates at atmospheric pressure.

The feedstock can be almost completely gasified, while non-combustible material, including glass and metal, is reduced to an inert slag. The product gas typically has a heating value approximately 1/4 to 1/3 the heating value of natural gas (natural gas has a value of approximately1040 BTU/standard cubic foot); therefore, it may be used as an efficient fuel source for industrial processes, including the generation of electricity, and the production of methanol and ethanol. The slag can be used in the construction industry or for road paving. All other byproducts, such as scrubber water and cyclone catch material, can be recycled into the process for reprocessing to alleviate disposal requirements.

[4] Brownlyn Duffy and Peter Nelson, *Emissions from Gasification Process*, April 1997

Distributed Generation

Distributed generation refers to modular systems that generate or store electricity and that are located near the point of use of the electricity. They can include wind power, photovoltaics, and biomass-based generators, including anaerobic digestion and gasification. The energy from distributed energy systems can either be connected to the grid or operate independently of the grid. In contrast to large, central-station power plants, distributed power systems typically range from less than a kilowatt (kW) to tens of megawatts (MW) in size. Distributed power technologies provide site-specific benefits to end-use customers and electric utilities, such as high power quality, improved reliability, and low-cost power delivery. Anaerobic digestion and gasification technologies have been used successfully as distributed generation systems.

Existing and Planned Facilities

Currently two facilities in California produce ethanol. Parallel Products, in Southern California, produces between 6 and 12 million gallons of fuel-grade ethanol annually. Parallel Products uses a variety of feedstocks, including mislabeled and expired alcoholic beverages, beverage syrups, candy, and other sugar products. Recently, the Renewable Fuels Association announced that Golden Cheese Company, located in Corona, California, has started production of ethanol derived from whey residue left over from cheese processing.

Three projects are in the planning and/or construction phases. BC International (BCI), of Dedham, Massachusetts, has two hydrolysis projects underway in California that would utilize rice straw and forest/saw mill residue; both of these projects are in the process of obtaining funding. Masada has one project underway in New York that would use municipal solid waste. These are briefly described below.

BC International, Gridley Ethanol Project

BCI's project in Oroville (Butte County) will use rice straw as a feedstock for conversion to ethanol (although the project is referred to as BCI Gridley, the actual facility would be in Oroville). The open-field burning of rice straw is being phased out, creating an interest in alternative applications for this residue. The proposed site is located adjacent to a biomass-to-energy facility, thus taking advantage of the synergy from co-location and use of similar feedstock. The biomass-to-energy facility would supply electricity to the ethanol facility and the residual lignin from the conversion process would be used as fuel at the energy facility. The project would use approximately 300,000 bone dry tons of rice straw and produce approximately 20 million gallons of ethanol annually.

BCI, Collins Pine Ethanol Plant

BCI's Collins Pine project would be located in Chester (Plumas County) and would convert forest thinnings and wood wastes into ethanol. As in the Gridley project, the Collins Pine project would be located adjacent to an existing biomass-to-energy facility to take advantage of the common feedstock, electricity production, and lignin utilization. The project would use approximately 300,000 bone dry tons of feedstock and produce approximately 20 million gallons of ethanol annually.

Masada Oxynol

Masada will be constructing a facility in Middletown, New York that will convert 90 percent of the MSW and biosolids into ethanol. In addition to removing traditional recyclable materials, the facility will have a capacity to process up to 230,000 tons of municipal solid waste and sewage sludge annually to produce 9.5 million gallons of ethanol a year. Masada already has contracts in place to sell the gypsum and lignin residue, which would provide an additional revenue stream.

IV. ECONOMIC EVALUATION

Two California Energy Commission (CEC) reports provide information regarding the economics of converting different feedstocks into ethanol. CIWMB staff is unaware of other reports that contain information on the economics of other conversion technologies. This section describes some of the CEC's findings and discusses their applicability to conversion technologies co-located at MRFs.

Hydrolysis currently is used in the midwestern United States to produce approximately 1.6 billion gallons of ethanol from corn. Approximately 12 million gallons per year of ethanol is produced today in California. However, the market potential could exceed 1 billion gallons per year by 2002[5], so there is no question that there is a very large market for ethanol. Out-of-state ethanol prices range from $1.35 to $ 1.45 per gallon for volumes up to 700 million gallons per year and might be $2.00 per gallon for volumes greater than 700 million gallons.[6]

One contributing factor in the cost of ethanol production in the midwest is the price of corn. If ethanol were to be produced in California from organic or other municipal residuals, the cost of production and the size of the facility would similarly be a function of feedstock cost and availability. A large ethanol facility would need more feedstock, which would require longer transport distances and quite possibly lead to higher ethanol production prices. It may be reasonable to have several smaller ethanol facilities (e.g., less than 20 million gallons annually) located near the source of feedstock, for example at MRFs, rather than to have larger conversion facilities that would necessitate longer transport distances for feedstock.

As described above (see Section II, "Back to the Future"), the CEC's 1999 report, "Evaluation of Biomass-to-Ethanol Fuel Potential in California," included several scenarios involving the use of urban residuals for ethanol production, for facilities ranging in size from 30 to 50 million gallons per year. The report also contained comparative data for the production of ethanol from corn utilizing wet mill and dry mill technology. Wet mills are usually much larger, ranging from 50 to 200 million gallons annually. Dry mill ethanol production capacities are typically in the range of 10 to 30 million gallons per year and would be the most applicable comparison for ethanol production facilities in California.

[5] California Energy Commission, "*Evaluation of Biomass Alternatives to Ethanol Fuel Potential in California*," December 1999.
[6] Ibid.

Table 2 below summarizes data from the report and compares modeled costs of ethanol produced in California from urban residuals with actual costs of ethanol produced in the Midwest from corn. The modeled production cost and target price for California ethanol are favorable when compared to the actual cost and price for the dry mill process using corn.

Table 2 - Ethanol Cost Comparisons

	California Produced Ethanol ($/gallon)		**Out-of-State Produced Corn Ethanol ($/gallon)**	
	Standalone facility	Co-located (biomass facility)	Dry Mill	Wet Mill
Production Cost	0.84 – 1.19	0.64 – 1.07	1.07 – 1.35	0.97 – 1.14
Target Price	1.08 – 1.79	0.83 – 1.32	1.35 – 1.45	

Source: *Evaluation of Biomass-to-Ethanol Fuel Potential in California and Appendices,* California Energy Commission, December 1999

The CEC used several assumptions to model costs in these scenarios. One assumption was an average cost of $14.50 per ton (including transportation) of urban waste feedstock. The average cost of landfilling in California is $40.00 per ton (noncompacted)[7], so one could assume that MRF operators are landfilling their residuals at about this price, although this will vary regionally. Given this average landfill tipping fee, the CEC's assumed cost of using these materials as feedstock for ethanol conversion would be very competitive. However, if an ethanol facility was co-located at a MRF, there either would be no disposal cost or the cost could be much less because the feedstock would be converted onsite and thus avoid the need for disposal. In addition, ethanol conversion residuals are marketable commodities -- lignin can be sold as biomass fuel and gypsum can be sold as soil amendment or to wallboard manufacturers. Thus, the economics of ethanol production from municipal residuals may be more favorable than CEC estimated.

Capital costs for an ethanol facility will vary depending on the technology used and size of the facility. For example, the CEC report included eight scenarios for ethanol facilities co-located at biomass facilities and using urban residuals as a feedstock. The total capital investment used for the scenarios ranged from $76 million for a 30 million gallon facility to $176 million for a 50 million gallon facility.

One possible co-location scenario is a 30 million gallon per year ethanol facility at a MRF that converts approximately 389,000 bone dry tons of MRF residuals into ethanol (Table 3). Such a facility would have a capital cost of approximately $76 million. In the scenario, the ethanol production cost of $0.75 already includes the cost of the feedstock. Table 3 summarizes this particular scenario, which shows a projected net profit of $7.7 million annually. This scenario does not include potential revenue from the sale of lignin to biomass facilities and gypsum as soil amendment or to wallboard manufacturers. A similar analysis has not yet been conducted for a smaller (e.g., 10 million gallon per year) ethanol facility co-located at a MRF.

[7] Source: 2000 CIWMB Landfill Tipping Survey

Table 3 - Urban Feedstock Scenario

Cost	Quantity			Total
Total Capital Investment			$	75,843,000.00
Annualized Cost	20 year term		$	3,792,150.00
Annual O/M Assumption		20%	$	758,430.00
Annual Capital and O/M Cost			$	4,550,580.00
Annual Cost plus annual feedstock cost			$	4,550,580.00
Model Assumption (Wholesale):	30,000,000	gallons annually		
Cost of Ethanol Production	$ 0.75			
Target Ethanol Price	$ 1.03			
Revenue Margin	$ 0.28			
Projected ETOH Revenue	$ 8,400,000.00	**Price/Ton**	**Annual Feedstock Quantity**	
Feedstock Revenue	$ 3,898,500.00	$ 10.00	389,850	
Gross Revenue	$ 12,298,500.00	***Urban Feedstock = waste paper, tree prunings***		
Annual Cost	$ 4,550,580.00	***urban wood waste, yard waste***		
Net Revenue	$ 7,747,920.00			

V. COMPARING LIFE CYCLE COSTS AND BENEFITS

One question about conversion technologies is how the costs, environmental impacts, and product streams of any one technology compare with those of other technologies and with other methods of managing the same materials. It would be extremely useful to know the net energy output for different technologies using the same types and amounts of materials, and how this compares with net energy output associated with, for example, recycling of paper.

A general methodology known as "Life Cycle Assessment" (LCA) may be useful in the future in evaluating these issues. Several published analyses that at least partially embody the LCA approach, most conducted under the auspices of the National Renewable Energy Laboratory (NREL), look at products and technologies related to conversion technologies.

However, the CIWMB is unaware of published LCA studies that evaluate these issues for the conversion technologies and urban feedstocks of concern in this paper.

General Description of "Life Cycle Assessment" Approach

LCA is a systematic method of identifying and evaluating the costs and environmental impacts associated with a specific process or group of processes. It attempts to quantify emissions, resource use, and energy consumption of all "life cycle stages" in a process, from acquisition, transportation, and transformation of raw materials, to manufacture into products, to final disposal of all products and by-products. LCA typically has been used to assess impacts from different stages of a product's development and manufacture. However, it also can be used to analyze and compare the environmental performance of waste management methods. In either case, it provides a framework for assessing tradeoffs and transfers of environmental risks from one environmental medium to another or from one life cycle stage to another.

The first major step in an LCA is the inventorying of all energy and raw material inputs and waste outputs associated with a particular product or a management system (such as a conversion technology). The next step is to assess the potential environmental and human health impacts associated with a given system based on the inventory results. LCAs typically do not include other important factors such as political pressures, social costs and benefits, and aesthetics.

In the mid-1990s, the U.S. Environmental Protection Agency (U.S. EPA), along with the U.S. Department of Energy (U.S. DOE), provided funding to the Research Triangle Institute and several partners to apply LCA concepts to and develop models and tools for evaluating solid waste management systems. This research is designed to evaluate tradeoffs through all life-cycle stages -- including raw materials acquisition, product manufacturing, and disposal and waste management -- among environmental emissions, energy, and costs for different management systems.[8] The models and tools include components for collection, separation, transportation, material recovery facilities, transfer stations, reprocessing recyclables, composting, combustion, and landfilling. Final documentation and publications may be available in Spring 2001. The model does not, at this time, include a component for conversion technologies.

<u>Electricity Production From Gasification, Using Tree Crops</u>

One published LCA examined the production of electricity when biomass was used as feedstock in a gasification system.[9] In this case, the system consisted of three major components:

1. growing tree crops (i.e., biomass) specifically for use as a feedstock;
2. transporting the feedstock to the gasification plant; and
3. generating electricity.

The study found that net energy production was highly positive, with one unit of energy required to produce approximately 16 units of electricity that can be sent to the grid. Over ¾ of all energy consumed in the system occurred during the production of the biomass feedstock.

Air emissions – carbon dioxide, isoprene, nitrogen oxides (NOx), non-methane hydrocarbons, and sulfur oxides (SOx) – were found in all three components, but primarily from feedstock production and power plant operations. Most (62 percent) carbon dioxide emissions occurred during feedstock production, which is consistent with the relatively high consumption of energy that occurred at that time. NOx, SOx, and particulate emissions from the power plant were well below emissions levels required by New Source Performance Standards for fossil-fueled plants. Particulate emissions were more than six times greater during the two years of plant construction than during normal operation.

[8] Weitz, K.A., S.R. Nishtala, and S.A. Thorneloe, "*Towards Sustainable Waste Management Using a Life-Cycle Management Decision Support Tool.*" [add citation]
[9] Mann, M.K., and P.L. Spath, *"Life Cycle Assessment of a Biomass Gasification Combined-Cycle System."* National Renewable Energy Laboratory (Boulder, CO), NREL/TP-430-23076, December 1997.

Most emissions to water occurred during feedstock production. In general, though, the study found that the total amount of water pollutants was small compared to other emissions. Transportation of the biomass feedstock to the power plant required fewer resources and energy and generated less air and water emissions than feedstock production and power plant operations.

Fuel Oxygenate Production from Hydrolysis, Using Agricultural and Forest Biomass

Another study estimated theoretical emissions and energy consumption associated with using hydrolysis to convert three feedstocks (rice straw, forest residue, and chaparral) to ethyl tertiary-butyl ether (ETBE), in comparison with open-field burning of these materials and their use in producing MTBE.[10] MTBE has been used in California as a fuel oxygenate, but its production and use has also caused groundwater contamination. ETBE is a fuel oxygenate that can be used as a substitute for MTBE.[11]

The study estimated that producing ETBE by acid or enzyme hydrolysis from all three feedstocks would result in lower emissions of Clean Air Act criteria pollutants – including non-methane hydrocarbons, carbon monoxide, oxides of nitrogen, and particulates – in all cases. Emissions of carbon dioxide were lower in all but one case, for ETBE produced by acid hydrolysis using chaparral as a feedstock. Total energy consumption was lower for ETBE produced by enzyme hydrolysis for all three feedstocks, but higher for ETBE produced by acid hydrolysis.

However, ETBE production would result in higher emissions to water, particularly of nitrates. This is because corn steep liquor is used during ethanol fermentation in hydrolysis. While nitrate emissions would not result from hydrolysis itself, corn steep liquor is produced during corn milling and has nitrates emissions associated with its production. These emissions would occur where the corn is milled.

Biomass-to-Energy Production in California

NREL also estimated the net environmental benefits that California receives annually by using biomass fuels in the "traditional" biomass-to-energy industry.[12] To do so, it estimated the environmental impacts (e.g., air emissions) of biomass-to-energy facilities; impacts if the biomass fuels currently used at these facilities instead were managed or disposed in other ways (i.e., assuming a total collapse of the California biomass-to-energy industry); and impacts from the fossil fuel production that would be needed to replace the lost biomass-to-energy production. Under this total collapse scenario, NREL estimated the portions of biomass materials that would be landfilled, burned in fields, used as kiln boiler fuel, left to accumulate in forests, or be converted to compost and mulch. NREL then assigned economic values (costs) to the emission impacts of biomass-to-energy production, alternative management/disposal methods, and fossil fuel energy production.

[10] Kadam, K.L., V.J. Camobreco, B.E. Glazebrook, et al, *"Environmental Life Cycle Implications of Fuel Oxygenate Production from California Biomass."* National Renewable Energy Laboratory (Boulder, CO), NREL/TP-580-25688, May 1999.
[11] The study did not assess the relative risks to groundwater of producing MTBE or ETBE.
[12] Information and data taken exclusively from: National Renewable Energy Laboratory (NREL), *Biomass Energy Production in California: The Case for a Biomass Policy Initiative*, November 2000.

In general, NREL found that air pollution – SOx, NOx, particulate matter, carbon monoxide, volatile organic chemicals, and green house gas emissions -- from open burning, landfilling, and forest accumulation is the main environmental impact of not using biomass fuels to produce energy. In contrast, NREL estimated that all these emissions are greatly reduced when the biomass is used for biomass-to-energy production.

NREL calculated the annual net economic value of California's biomass-to-energy industry by adding its estimated costs of alternative management/disposal methods ($563 million) to the estimated cost of fossil fuel energy production ($74 million), and subtracting the cost of biomass-to-energy production ($268 million) (Table 5). The net environmental result of biomass-to-energy production – i.e., the public benefits of cleaner air, reduced loading of landfills, reduced emissions of greenhouse gases, and healthier and more productive forests and watersheds -- was estimated to be a benefit of $369 million per year. Social benefits, such as rural employment, economic development, and energy diversity and security, were not included.

Table 5. Estimated Costs and Benefits of Biomass-to-Energy Production in California, 1999

Alternative Management/Disposal Method	**Cost/Year (in $ million)**
Open Burning --1.7 million tons/year open burned (730,000 tons forest residue; 950,000 tons agriculture residue)	$ 173.5
Forest Accumulation -- 490,000 tons/year of forest residue left in forest	$ 62.7
Burial in Landfill -- 3.0 million tons/year landfilled (1.5 million tons from wood-processing; 106,000 tons of agriculture residue; 1.4 million tons of municipal waste wood)	$ 251.4
Compost & Mulch -- 370,000 tons/year to produce compost and mulch (126,000 tons wood-processing waste; 241,000 tons municipal wood)	$ 19.7
Kiln Boiler -- 886,000 tons/year of sawmill residue used for energy production in sawmill kiln burners	$ 55.8
Total Disposal/Management Cost If Not Used For Biomass-to-Energy	$ **563.1**
Cost of Fossil Fuel Energy Production	$ **74.3**
Cost of Biomass-to-Energy Production	($ **268.4**)
Net Benefit of Using 6.4 Million Tons for Biomass-to-Energy = $ 563.1 + $ 74.3 - $ 268.4 = $ 369.0	**$ 369.0**

VI. BARRIERS TO DEVELOPING CONVERSION TECHNOLOGIES

Based on discussions with a variety of stakeholders, barriers and issues related to the development of conversion technologies range the gamut: whether conversion technologies are technologically amenable to use of urban feedstocks; what their net environmental impacts are; how technologies can be funded to go from lab-scale to initial full-scale operations; how feedstock supplies can be made available; how financial institutions can assess whether markets are sufficient for proposed products; etc.

The May 3-4 forum will consist primarily of working groups to identify barriers and develop initial recommendations for overcoming them. The working groups on barriers, which will be conducted on the afternoon of May 3, will be broken into the following five groupings of issues/barriers. CIWMB staff prepared the following list, not necessarily exhaustive, of draft questions for each group to consider in its discussions. In addition, this section contains an initial list of potential mechanisms that might be considered if policies are formulated to assist in developing a biomass conversion technology industry in California.

1. Technology and Emissions Issues

Conversion technologies may be able to use only certain types of feedstocks, and their operating efficiencies may depend on the type of feedstock converted. The particular technology and type of feedstock utilized may also result in varying emissions to the environment (e.g., to air and water) and in varying residuals from the process itself (e.g., lignin, gypsum). Some questions to consider include:

Technology-Related Issues

- What feedstocks or mixes of feedstocks, meeting what specifications or guidelines, are amenable for use by different conversion technologies? What dictates "quality" feedstock for a conversion facility, and how critical is this?
- What specific R&D is needed for different technologies?

Environmental Emissions Issues

- What are the environmental impacts of different conversion technologies relative to existing biomass-to-energy plants, "traditional" recycling, and disposal? In which cases might net emissions be an improvement, or when might they exacerbate existing problems? Are closed-loop systems feasible?
- Does storage of feedstock pose any problems?
- What changes in and impacts from transportation might be expected?
- What, if any, additional research on the life-cycle environmental costs and benefits of conversion technologies is needed?

2. Siting/Permitting Issues

Currently there are no facilities in California utilizing conversion technologies such as hydrolysis or gasification, so siting and permitting issues are unknown at this time. Existing statutes and regulations may or may not hinder the co-location of conversion facilities at MRFs or landfills. Questions related to siting and permitting include:

- Can (and should) facilities be sited near feedstock supplies, such as at material recovery facilities (MRFs)?
- Which agencies (e.g., CIWMB; Local Enforcement Agencies; Bureau of Alcohol, Tobacco, and Firearms; California Energy Commission; Air Quality Management Districts) have permitting jurisdiction over a conversion facility co-located at, for example, a MRF? What type of permit modifications or California Environmental Quality Act (CEQA) requirements might be required for such a co-located facility? Do existing regulations cover this situation adequately, or are revisions needed?
- What other effluent and materials management issues may impact other required permits (such as Water Discharge Requirements, National Pollution Discharge Elimination System permits, and Resource Conservation and Recovery Act permits)?
- What are the permit requirements for a conversion research/pilot project at a solid waste facility?

3. Financing/Commercialization Issues

The construction of conversion facilities is very expensive and acquiring financing may be problematic. For some technologies such as hydrolysis, the transition from pilot scale to commercial scale facilities may pose some problems. Questions to consider include:

- What are barriers to successful commercialization of new conversion technologies and continued operation of existing biomass-to-energy facilities?
- Although much research has occurred, which technologies that can utilize municipal residuals as feedstock are ready for commercialization and which still require additional R&D?
- What methods are available to secure public and/or private funding for construction and operation of new facilities?
- Are lending institutions and venture capitalists ready to provide financing?
- How can the "first" conversion technology projects be funded?

4. Public Perception Issues

Fear of the unknown is very powerful. The fact that some of the conversion technologies (i.e., hydrolysis) described in this document have not been completely commercialized may exacerbate public fears and perceptions about the environmental impacts of these technologies. Questions related to public perception include:

- Are there public concerns about environmental impacts associated with new conversion technological processes and products? Are there environmental justice implications?
- Is the public more likely to support such technologies?
- Could conversion technologies be perceived as weakening traditional recycling programs?
- Could conversion technologies be perceived as helping to solve the State's energy problems?

5. Economic and Market Issues

The long-term viability of a conversion facility is dependent on a number of factors, including access to feedstock and markets for products. Questions about economic issues for conversion facilities include:

- Will conversion facilities typically compete with landfills for feedstock? E.g., will a conversion facility that utilizes MRF residuals for conversion have to compete with a landfill for the materials?
- What are the transportation costs of feedstock if a conversion facility is not co-located at a MRF?
- What are the cost-savings if a conversion facility is co-located at a MRF?
- Are the purported benefits of conversion technologies – such as reduced landfill emissions and leachate, reduced air pollution, reduced transportation costs, production of fuels and other products, etc. – fully internalized?
- What is the status of markets for the potential products of conversion technologies? Do State policies promote or preclude market development for particular products?

Potential Mechanisms For Overcoming Barriers

To date, mechanisms that may be appropriate to assist in developing a biomass conversion technology industry in California have not been fully discussed. What, if any, mechanisms should be implemented, and what is their appropriate level and timeframe? Day 2 of the forum will consist of working groups that are charged with developing recommendations on how to overcome the barriers identified in Day 1. To stimulate this discussion, CIWMB staff have compiled the following examples of potential mechanisms – in no particular order, and not necessarily comprehensive or limited to -- for overcoming barriers:

- Direct monetary provisions (e.g., grant programs, pilot/demonstration projects)
- Increased public financing (e.g., California Pollution Control Financing Authority; underwriting financing)
- Market incentives (e.g., renewable fuels standard, minimum renewable energy generation and purchase requirements)
- Guaranteed ethanol markets (e.g., oxygenate requirements, public fleet requirements)
- Public education/outreach (e.g., on benefits of replacing petroleum)
- Technology Vendor Conference
- Research and development funding
- Lifecycle assessment funding
- Air emissions offset credits
- Landfill diversion credits
- Formal State interagency biomass task force
- Tax incentives (e.g., investment, feedstock utilization, and energy production credits)
- Zoning for co-located facilities
- Certification of new, innovative technologies
- Permit streamlining
- Feedstock quality guidelines

APPENDIX 1. LEGISLATIVE AND PROGRAMMATIC HISTORY

Legislative and programmatic activities generally have not directly addressed conversion technologies, with the exception of some definitions in the Integrated Waste Management Act. Several statutes and programs concern the use of agricultural, forest, and urban residues at biomass-to-energy plants. This appendix briefly summarizes these definitions, legislation, and programs.

State Initiatives

AB 939 Definitions

Assembly Bill 939 was the landmark legislation that required cities and counties to divert 25 percent of their waste from landfills by 1995 and 50 percent by 2000. Jurisdictions have relied on a number of programs such as curbside recycling and composting to help them achieve their mandated goals. Despite these efforts, the overall state diversion rate is 42 percent.

To achieve its diversion goal, a jurisdiction is able to count no more than 10 diversion credit for materials used in transformation. Transformation is defined as incineration, pyrolysis, distillation, gasification, or biological conversion; it does not include composting or biomass conversion. Biomass conversion is defined as the controlled combustion, when separated from other solid waste and used for producing electricity or heat, of the following materials: 1) agricultural crop residues; 2) bark, lawn, yard, and garden clippings; 3) leaves, silvicultural residue, and tree and brush pruning; 4) wood, wood chips, and wood waste; and 5) nonrecyclable pulp or nonrecyclable paper materials.

A jurisdiction that has a transformation or biomass-to-energy facility that was operating prior to 1996 can claim up to 10 percent diversion if materials are going to those facilities. However, any new facilities that convert residuals cannot claim a 10 percent diversion credit because these facilities will not have been in operation prior to 1996. This would include hydrolysis (and subsequent distillation), gasification, pyrolysis, or other types of biological conversion facilities.

Assembly Bill 1890 and Related Legislation: Electricity Deregulation

In 1996, AB 1890 (Chapter 854, Statutes of 1996) established a funding pool administered by the California Energy Commission (CEC) of up to $540 million for renewable energy, for the period 1998 to 2001. The CEC submitted a report to the Legislature in 1997 with recommendations on how the funding should be allocated. The Legislature incorporated the recommendations into SB 90 (Chapter 905, Statutes of 1997, Sher) and directed the CEC to administer a renewables transition fund (RTF) program and other related activities.

SB 1194 (Chapter 1050, Statutes of 2000, Sher) and AB 995 (Chapter 1051, Statutes of 2000, Wright), identical pieces of legislation, continued the recognition that renewable energy provides California with environmental benefits and requires assistance to survive the deregulated energy market. The legislation established a funding pool of $135 million per year through January 2012, with funds to come from ratepayers of private utilities for investing in renewable energy resources.

AB 1890 also directed Cal/EPA to evaluate the economic and environmental benefits of the biomass industry and identify strategies that shift industry costs away from ratepayers and onto other beneficiaries of biomass. A report, "Cost Shifting Strategies for the Benefits Attributable to the Solid Fuel Biomass Industry" was submitted to the Governor's Office in 1998.

Assembly Bill 2273, Cost-Shifting Strategies

Subsequently, AB 2273 (Chapter 816, Statutes of 1998) required Cal/EPA to prepare an annual report on the existence, status, and progress of any public policy measures related to cost-shifting strategies developed as a result of the recommendations made in the report required by AB 1890. The first report, "Status of Cost-Shifting Strategies of Biomass-to-Energy Industry," was submitted to the Governor's Office in March 1999. The second report is on the CIWMB's April 2001 Board Meeting agenda for consideration.

Assembly Bill 3345, Agricultural and Forest Waste Utilization

AB 3345 (Chapter 991, Statutes of 1996) required the CIWMB to conduct a feasibility study on expanding the use of agricultural waste and forest waste in the production of commercial products. The CIWMB prepared a report that included the available technologies and commercial products that could be manufactured from agricultural and forest waste. The report, "Feasibility Study on the Expanded Use of Agricultural and Forest Waste in Commercial Products," was submitted to the Governor and the Legislature in 1999.

Senate Bill 318, Rice Straw Demonstration Project Fund

AB 318 (Statutes of 1997) created the Rice Straw Demonstration Project Fund and directed the California Air Resources Board to administer a program whose goal was to help create a market for Sacramento Valley rice straw. Creation of commercially sustainable uses of rice straw would help in reducing the amount of rice straw that is open-field burned.

Assembly Bill 1515, Nonyard Woodwaste Report

AB 1515 (Chapter 717, Statutes of 1991) required that the CIWMB prepare a report on the quantities of nonyard woodwaste diverted from permitted disposal facilities in California and assess the environmental and economic impacts of promoting or discouraging nonyard wood waste diversion from those facilities. The report had various conclusions regarding the definition of nonyard woodwaste, AB 939 diversion credits and solid waste facility permitting issues and the need for quantification of wood waste. In addition, the report stated that biomass facilities provide an alternative to disposal of woodwaste in landfills while at the same time generating electricity and that biomass facilities assist in reducing air emissions of criteria pollutants by burning agricultural waste in a controlled environment.

Assembly Bill 2514, Agricultural Biomass Utilization Account

Assembly Bill 2514 (Chapter 1017, Statutes of 2000) creates the Agricultural Biomass Utilization Account in the Department of Food and Agriculture and appropriates $2 million from the General Fund. Grants will be given to applicants in an amount of no less than $20 per ton of rice straw utilized in a manner that avoids landfill use, preventing air pollution, and enhancing environmental quality.

Assembly Bill 2825, Agricultural Biomass to Energy Incentive Grant Program

Assembly Bill 2825 (Chapter 739, Statutes of 2000) enacts the Agricultural Biomass to Energy Incentive Grant Program, which permits air districts to apply to the Trade and Commerce Agency to receive grants to provide incentives to facilities that convert qualified agricultural biomass to fuel. The air districts apply on behalf of biomass facilities in their district. It is also the intent of the Legislature to provide funding of thirty million dollars ($30,000,000) over the three-year duration of the grant program. Grants will be given in the amount of $10 per ton of qualified agricultural biomass received for conversion to energy.

Qualified agricultural biomass is defined as any agricultural residues that historically have been open-field burned in the jurisdiction of the air district from which the agricultural residues are derived, as determined by the air district. Agricultural residues include either of the following: (1) Field and seed crop residues, including, but not limited to, straws from rice and wheat. (2) Fruit and nut crop residues, including, but not limited to, orchard and vineyard pruning and removals. Urban and forest products are excluded from the definition of qualified agricultural biomass. In FY 2000/2001, the Trade and Commerce Agency awarded grants through the air quality management districts to 11 biomass-to-energy facilities. Grant payments are expected to begin in May 2001.

Federal Initiatives

Executive Order 13134 – Developing and Promoting Biobased Products and Bioenergy

Executive Order 13134, signed by President Clinton on August 12, 1999, included research, development, and private sector incentives to stimulate the adoption of technologies needed to make biobased products and bioenergy cost-competitive in large national and international markets. This would be accomplished by establishment of the:

1. **Interagency Council on Biobased Products and Bioenergy (Council).** The Council, composed of the heads of relevant Federal agencies, was required to prepare an annual strategic plan which outlines the overall national goals in the development and use of biobased products and bioenergy.
2. **Advisory Committee on Biobased Products and Bioenergy**. The Advisory Committee was to provide information and advice for consideration by the Council. It was to have up to 20 members including representatives from the farm, forestry, chemical, manufacturing and other sectors; energy companies; electric utilities; environmental and conservation organizations; university research community; and other critical sectors.
3. **National Biobased Products and Bioenergy Coordination Office.** The Secretaries of Agriculture and Energy were required to establish the Coordination Office to ensure effective day-to-day coordination of actions designed to implement the strategic plans and guidance provided by the Council and respond to recommendations made by the Committee.

Biomass Research & Development Act of 2000

The Biomass Research & Development Act of 2000 (H.R. 2559, incorporated as part of Public Law 106-224), complemented and/or superceded the President's Executive Order on Biobased Products and Bioenergy. Its major thrust is to improve interagency coordination and focus federal research and development (R&D) efforts on the conversion of biomass into biobased industrial products. The Act authorizes $49 million in R&D funding at the U.S. Department of Agriculture for bioproducts development, and establishes a Biomass R&D Technical Advisory Committee and a Biomass R&D Interagency Board to coordinate and oversee activities related to the initiative. The R&D Interagency Board takes the place of the Interagency Council previously established under Executive Order 13134. The Technical Advisory Committee supercedes the Advisory Committee under the Executive Order, and includes some changes to the selection process and the roles and responsibilities of the members.

APPENDIX 2. FUNDING PROGRAMS

Several funding sources, both in California and nationally, could possibly be of use for conversion-related activities. Statewide grant funding has been devoted primarily towards the conversion of agricultural residues into energy at biomass-to-energy facilities, with one program focusing primarily on rice straw utilization.

State Funding

Agricultural Biomass-to-Energy Incentive Grant Program

The Trade and Commerce Agency implements the Agricultural Biomass-to-Energy Incentive Grant Program mandated by AB 2825. The intent of AB 2825 is to offset the higher costs of agricultural biomass delivered by growers to biomass-to-energy facilities. The legislation provided $30 million over a three-year period to establish an incentive grant program. The incentive is $10 per ton for qualified agricultural biomass converted to electricity. In 2001, the Trade and Commerce Agency awarded nearly $9 million in grants to seven air districts, representing eleven facilities to increase the use of qualified agricultural biomass and reduce open-field burning.

Rice Straw Demonstration Project Fund

The Rice Straw Demonstration Project Fund (Rice Fund) was created by SB 318 and directed the California Air Resources Board to provide incentive grants for the development of commercial uses for rice straw. The incentive grants can fund up to 50% of a project that utilizes rice straw grown in the Sacramento Valley. A total of $4.2 million has been awarded from the Rice Fund. Recently, SB 1794 (Chapter 1019, Statutes of 2000) extended the program for an additional three years.

Public Interest Energy Research Program (PIER)

The California Energy Commission administers the PIER Program, which provides funding to public and private entities for research, development, and demonstration activities that advance energy-related science and technology not adequately provided for by competitive or deregulated markets. Funding for PIER, initially under AB 1890 and subsequently SB 1194 and AB 995, is available for advanced generation and renewables technologies, end-use efficiency, and environmental and strategic research. PIER planned three programmatic solicitations for release in 2000-2001. The first solicitation addressed efforts to make renewable energy production more affordable; the other solicitations will address reliability and the ability of renewable energy to capture environmental benefits.

The PIER program has funded several other projects intended to help California's biomass-to-energy industry become more cost-competitive:

- In November 1999, the CEC released $1.3 million in funding for small-scale modular biomass power projects. The funding was targeted to biomass-fueled distributed energy systems to address environmental problems associated with open-fuel burning of agricultural residuals, wildfires from forest overgrowth, and urban wood waste in landfills.
- In the second quarter of 2000, CEC released another $1.63 million to fund two small modular biomass projects.
- The CEC also has a $340,000 co-funding agreement with the Electric Power Research Institute (EPRI) to assess the renewable energy technology markets in California. The research will address the current market needs and future market trends of renewable energy and quantify benefits from renewable energy generation.

California Pollution Control Financing Authority (CPCFA)

The CPCFA provides California businesses with an affordable method of financing pollution abatement equipment, waste disposal, and resource-recovery facilities for the management of environmental pollution hazards. CPCFA offers tax-exempt or taxable bonds and loan portfolio insurance to businesses seeking financing for qualified pollution control projects. CPCFA plays a key role in achieving federal and state environmental standards while assisting businesses to purchase state-of-the-art equipment that directly improves the bottom line in business management. The CPCFA assists businesses in meeting environmental standards, so they can continue operating in California. Specifically, CPCFA seeks to:

- Assist the private sector in achieving the economic benefits of tax-exempt bond financing
- Develop programs to overcome the barriers to obtaining capital for pollution control technologies
- Increase access to capital markets for small businesses

The CPCFA offers two tax-exempt bond programs, the Large Business Pollution Control Tax-exempt Bond Program and the Small Business Pollution Control Tax-exempt Bond Program. The Large Business Pollution Control Tax-exempt Bond Program provides bond financing to California businesses, irrespective of company size, for the acquisition, construction, or installation of qualified pollution control, waste disposal, and resource recovery facilities. This program offers a lower-investment grade debt service as well as a minimum $20 million or more for financing.

The Small Business Pollution Control Tax-exempt Bond Program provides tax-exempt bond financing to small businesses for the acquisition, construction, or installation of qualified pollution control, waste disposal, and resource recovery facilities. Types of projects that may qualify for financing include curbside collection facilities, recycling facilities, composting facilities, materials recovery facilities, transfer stations, landfills, waste-to-energy facilities, qualified air or water pollution control projects, and qualified solid waste control or hazardous waste disposal projects.

To qualify, the business must be legally classified as a small business. Offering financing in amounts from $1 to $20 million, this program for small businesses also provides a lower debt service and a longer pay back period than conventional financing generally allows.

In addition, the CPCFA provides loan assistance for small businesses. The California Capital Access Program (CalCAP) offers loan portfolio insurance for banks to encourage banks to make loans to small businesses, which carry higher than conventional lending risk. CalCAP is available through banks statewide. With some exclusions, virtually any business loan is eligible under CalCAP. The maximum loan amount is $2.5 million and a bank can enroll all or a portion of a loan under CalCAP.

Recycling Market Development Zone (RMDZ) Loans

The CIWMB's RMDZ revolving loan program provides direct loans to businesses that use postconsumer or secondary waste materials to manufacture new products or that undertake projects to reduce the waste resulting from the manufacture of a product. To be eligible, the business must be located in one of the 40 designated RMDZs and divert waste from California landfills.

Loan funds may be used for acquisition of equipment, leasehold improvements, working capital or acquisition of owner-occupied real property (limited to $500,000). Rates, terms, and fees are as follows:

- Each eligible business or local government agency may borrow up to 75 percent of the cost of a project, for a maximum loan of $2 million.
- The term of the loan is not to exceed 10 years (15 years if secured by real estate) and amortization schedules are based on the useful life of the asset being financed.

- Interest rates are fixed for the term of the loan, and are set by the CIWMB semiannually. The loan rate is 6.5 percent through December 31, 2000.
- A nonrefundable application fee of $300.00 is due at time of application submittal. A loan origination fee of one-half percentage points will be charged on each loan. Points are due at the time of closing. The points are an eligible loan expense.

Local governments may apply for funds to finance public works infrastructure that directly supports an eligible business.

Federal Funding

Federal agencies such as the Department of Commerce, Department of Energy, and the Department of Agriculture also administer a number of relevant funding programs. The following is a brief summary of some potential sources of funding. A more complete list and links to funding agencies can be found on the National Biobased Products and Bioenergy web site at http://www.bioproducts-bioenergy.gov/.

Advanced Technology Program

The National Institute of Standards and Technology, (NIST) Department of Commerce, manages the Advanced Technology Program (ATP). The ATP is a unique partnership between U.S. industry and government to enhance the nation's competitiveness - and economy - by developing new technologies. Through cooperative agreements with individual companies or groups of companies, large and small, the ATP invests in industrial projects to develop technologies. The ATP can fund up to $2,000,000 in research on a given project, subject to some cost sharing. Projects must be completed within 3 years. Two or more companies may propose a joint research venture under the ATP. Joint venture programs may run as long as five years, and the ATP can fund up to half of the research and development costs.

A total of 79 research and development projects were granted awards for the 1998 round of ATP funding. The projects will receive approximately $236 million from the ATP, which is expected to be matched by $24 million from private industry. The majority of the awards (54) went to small businesses, including new companies, either for single-company projects or as the lead company in an industry joint venture.

Approximately $60.7 million in first year funding for fiscal year 2001 is available for new awards. The actual number of proposals funded will depend on the quality of the proposals received and the amount of funding requested in the highest ranked proposals. Funding beyond the first year is contingent on the approval of future Congressional appropriations and satisfactory project performance.

National Industrial Competitiveness through Energy, Environment, and Economics (NICE^3)

The U.S. Department of Energy (DOE) sponsors an innovative, cost-sharing program to promote energy efficiency, clean production, and economic competitiveness in industry. The grant program provides funding to state and industry partnerships (large and small business) for projects that develop and demonstrate advances in energy efficiency and clean production technologies.

Industry applicants must submit project proposals through a state energy, pollution prevention, or business development office. State and industry partnerships are eligible to receive a one-time grant of up to $525,000. The industrial partner may receive a maximum of $500,000 in federal funding. Non-federal cost share must be at least 50 percent of the total cost of the project

Basic information on financial assistance available through the Office of Industrial Technologies (OIT) Inventions and Innovation (I&I) grant program, NICE[3] grant program, and the Industries of the Future (IOF) strategy is available in the *Guide to Financial Assistance for Technology Innovators*.

Department of Agriculture, Commodity Credit Corporation

The Department of Agriculture's Commodity Credit Corporation (CCC) recently announced final results for the fiscal year 2001 Bioenergy Program solicitation. Under the program, CCC will make payments to bioenergy companies to offset part of their cost of buying commodities to expand production. The CCC accepted a total of 54 agreements representing 79 plants in 19 States for participation in the program. The aggregate increase in production under these agreements, which were submitted by 42 ethanol and 12 biodiesel producers, is projected to be 246 million gallons of ethanol and 37 million gallons of biodiesel during the 10 months (December 2000 through September 2001) payments will cover. Eligible commodities included in the solicitation were barley, corn, sorghum, and wheat for ethanol and soybeans for biodiesel. Payments under the program are expected to be within the $150 million budgeted for Fiscal Year 2001.